(3 Hours) **Marks 80**

N.B. 1) Question No.1 is compulsory
2) Answer any three out of five question
3) Assume suitable data wherever necessary and state them clearly
4) Figure to the right indicate full marks

Q1

a) Write short note on liquid activity coefficient model. 05

b) Explain types of flowsheet simulation 05

c) List out the various methods of optimization and explain in brief. 05

d) Explain overall strategy for developing unit model 05

Q2 A flash unit operates at 1 atm and 373 K. A liquid feed comprised of methanol, propanol and acetone with an enthalpy of -264.6 kJ/mol enters the unit. No external heat is supplied. Determine the vapour fraction (V/F) based on the following data. The coefficients to determine the specific heat in J/(mol.K) are given in the table. The reference temperature is 298 K. The enthalpy of formation at standard state and the heat of vapourization at 373 K are given in kJ/mol. The vapour phase and liquid phase compositions are represented as mole fractions. 20

Component	Methanol	Propanol	Acetone
a	21.14	2.47	6.3
b	0.07	0.33	0.26
c	$2.59x10^{-05}$	$-1.85x10^{-04}$	$-1.25x10^{-4}$
d	$-2.85x10^{-8}$	$4.29x10^{-8}$	$2.04x10^{-08}$
H_f^0	-239	-303	-248
Hvap	32.39	41.47	26.16
x	0.40	0.23	0.37
y	0.39	0.05	0.56

Q3(a) 97 % acetone from air acetone vapour mixture is to be recovered by using absorption using water as a solvent at 300 K and 10 bar. The feed entering bottom of column consists of 9 moles of air and 1 mole of acetone. The operating pressure in column are 300 K and 10 bar respectively. The absorption factor for acetone is 1.4. calculate

i) Required flow rate of solvent
ii) Number of stages
iii) Composition of leaving vapour and liquid from absorption column

Data given: Vapour pressure of acetone = 0.322 bar
Vapour pressure of water = 0.035 bar

Q3(b) Steam reforming of methane is carried out at 773 K and 2 atm:- 10

CH_4 (g) + H_2 O (g)↔ CO (g) + $3H_2$ (g) ΔH = 206 kJ/mol

The standard Gibbs free energies of formation of methane, water and carbon monoxide are -50.8 kJ/mol, -228.61 kJ/mol and -137.16 kJ/mol respectively. The reference temperature is 298 K. Determine the partial pressures and vapour phase concentrations (mole fractions) of all the components at equilibrium

Q4 Feed streams with pure species A and B are mixed with a recycle stream in a CSTR, where the following reactions take place: 20

A + B → C + D

A + C → 2E

B + E → F

F is a gaseous product, D is a solid waste, C is a by-product while E is the main product. The plant consists of a reactor, a filter and two distillation columns. 98% of high boiling E is recovered from the first column, while volatile C is separated in the second column. Due to formation of an azeotrope, some of component C (equivalent to 10 wt% of component E) is retained in the column bottoms. 90% of this bottom product is recycled, while the rest is purged. Construct a Williams-Otto flowsheet and develop the process equations

Q5(a) Solve the following problem by Kuhn Tucker condition 10

Maximize $Z = -x_1^2 - x_2^2 - x_3^2 + 4x_1 + 6x_2$

Subject to $x_1 + x_2 \leq 2$

$2x_1 + 3x_2 \leq 12$ with $x_1, x_2 \geq 0$

Q5(b) Solve graphically the following problem(Lagrange Multiplier Method) 10

Maximise $Z=2X_1+3X_2$

Subject to

$X_1^2+X_2^2< 20$

$X_1*X_2<08$

$X_1,X_2>10$

Q6(a) Derive the equation for fugacity coefficient used in EOS model 10

Q6(b) Solve by Lagrangian Method 10

$S=2X_1X_2+2X_2X_3+X_1X_3$

$X_1X_2X_3=32$, &$X_1,X_2,X_3>0$
